Small Hydro Studies

Status Report

"This report contains information available up to October 1984. The information may be incomplete and subject to amendment as a result of further studies."

B.C. Hydro
Hydroelectric Generation Projects Division

Report No. H1771

October 1984

Canadian Cataloguing in Publication Data
Main entry under title:
Small hydro studies status report

"Report no. H1771".
ISBN 0-7726-0184-4

1. Hydroelectric power plants - British Columbia - Location. I. B.C. Hydro. Hydroelectric Generation Projects Division. Development Dept.

TK1427.B7S63 1984 333.91'4 C84-092275-2

B.C. HYDRO

SMALL HYDRO STUDIES

STATUS REPORT

Prepared by: R. Orm Holm
Project Development Section

Approved by: R. Orm Holm for E.M. Solmon
Manager, Development Department

OCTOBER 1984

HYDROELECTRIC GENERATION PROJECTS DIVISION

DEVELOPMENT DEPARTMENT

REPORT NO. H1771

SMALL HYDRO STUDIES STATUS REPORT

CONTENTS

Section	Subject	Page
	SYNOPSIS	iii
1.0	INTRODUCTION	1
2.0	ECONOMIC CRITERIA	2
3.0	PRELIMINARY ASSESSMENTS	3
	3.1 Atlin	3
	3.2 Fort Nelson	6
	3.3 Queen Charlotte Islands	8
	3.4 Stewart	12
	3.5 Anahim and Tatla Lakes	17
4.0	ASSESSMENT OF CHARLOTTE LAKE DEVELOPMENT	21
	4.1 General	21
	4.2 Hydrology	22
	4.3 Development Potential	24
5.0	CONCLUSIONS AND RECOMMENDATIONS	25
	5.1 Conclusions	25
	5.2 Recommendations	26
	REFERENCES	

TABLES

Table No.	
1	Charlotte Lake Regulated Monthly Outflows

FIGURES

Figure No.	
1	Maximum Unit Capital Cost to Satisfy 5-Year Loss Criteria
2	Atlin - Site Location Plan
3	Queen Charlotte Islands - Site Location Plan
4	Stewart - Site Location Plan
5	Anahim and Tatla Lakes - Site Location Plan

SYNOPSIS

Preliminary assessments have been made of the small hydro potential in six diesel power districts not connected to the integrated transmission system: Anahim Lake, Atlin, Fort Nelson, the Queen Charlotte Islands, Stewart and Tatla Lake.

The findings of the assessments are as follows:

1. There are no sites suitable for small hydro development in the Fort Nelson and Tatla Lake districts and no further studies should be planned for these districts.

2. There are potential sites on the Cascade River in the Stewart district and on Pine Creek in the Atlin district but development by B.C. Hydro would be subject to prior development claims by others. Further studies should be considered if these prior claims are relinquished.

3. The Ain River is the most promising site in the Queen Charlotte Islands district, but it has potentially prohibitive environmental constraints. Studies of other sites in the district should be postponed until the Ain River scheme has been studied.

4. A potential development at Charlotte Lake to supply electric power to the districts of Anahim Lake and Tatla Lake would be uneconomic based on the present load forecast and the criterion specified in draft corporate small-scale energy development policy which would limit losses associated with such developments to five years. Further studies should be considered only if there is a large increase in load or if a less restrictive economic criterion is adopted.

SMALL HYDRO STUDIES STATUS REPORT

1.0 INTRODUCTION

Engineering Assignment No. 482-100, dated 20 October 1982, authorized the Hydroelectric Generation Projects Division (HGPD) to conduct site selection studies in three diesel power districts not connected to the integrated transmission system. The object of the studies was to provide an inventory and comparative evaluation of all potential sites, to develop a project concept and preliminary cost estimate for the three most promising sites in each district, and to select one preferred site in each district for more detailed study.

A joint review by HGPD and System Engineering Division (SED) at the outset of the studies indicated six diesel districts which might benefit from small hydro development, namely: Anahim Lake, Atlin, Fort Nelson, the Queen Charlotte Islands, Stewart and Tatla Lake. (The locations of these districts are shown on the key plans on Figs. 2 to 5.) Field reconnaissance surveys were then conducted to make preliminary assessments of the small hydro potential in each district to aid the selection of the three most appropriate districts for study.

The four most northerly districts, Atlin, Fort Nelson, the Queen Charlotte Islands and Stewart were visited first, in October 1982, before the onset of winter. These reconnaissance surveys indicated that the extent of the site selection studies could be reduced from that envisaged when the engineering assignment was issued. Where small hydro potential existed, the most promising sites were readily identified. However, because of development constraints and other considerations discussed in more detail under the individual district headings, none of the four districts yielded a preferred site for more detailed study. Reconnaissance surveys of the Anahim

and Tatla Lakes districts took place as soon as weather and ground conditions permitted, in May 1983, but subsequent brief office studies did not indicate any promising sites. The lack of a promising site for more detailed study in any of the districts and higher priority studies for other assignments led to the deferral of this status report.

2.0 ECONOMIC CRITERIA

During the course of the assignment, a draft corporate policy for small-scale energy resource development was developed. The draft policy would support cost-effective development. In the case of areas not connected to the integrated transmission system (such as the diesel power districts under study), the basis for measuring cost effectiveness would be the expected present value of the total annual cost (capital and operating) over a maximum 20-year decision horizon, a significantly more stringent requirement than those applied to larger generation and transmission projects within the integrated system. The policy would also restrict the losses associated with small-scale energy developments to a five-year period, i.e. the point in time when the annual cost of service of the proposed development would become less than the forecast annual cost for supplying the equivalent energy from the existing supply source should not be beyond the fifth year of service. (The annual cost of service of a small hydro development declines over the early years of service because the revenue requirement is based on a 1.3:1 interest coverage ratio and straight line annual depreciation. Surplus revenue is then used to reduce the net outstanding dept, which reduces the subsequent interest expense and associated interest coverage.) The Strategic Planning Unit carried out a series of comparative cost-of-service studies to determine the maximum unit capital cost to satisfy the five-year loss criterion for a range of average capacity factors. The studies compared the cost of service of a small hydro development with the cost of

supplying the equivalent amount of energy with the existing diesel plant, assuming the capital expenditure profile and generation and operating cost characteristics of the small hydro development to be similar to those for the proposed Thorsen Creek project. The results are shown on Fig. 1.

It can be seen from Fig. 1 that for a small hydro project with an average capacity factor of 70% the unit capital cost should not exceed $5000.00 per installed kilowatt to satisfy the five-year loss criterion. This means that the lifetime average unit energy cost should not exceed 6.8¢/kWh (in 1983/84$, including 20% Corporate Overhead), a requirement that most small hydro developments would be unable to meet.

3.0 PRELIMINARY ASSESSMENTS

3.1 Atlin

a) Existing Service

B.C. Hydro's diesel station has an installed capacity of 1,750 kW. The peak demand in 1982/83 was 610 kW and the annual energy was 2.48 GWh.

b) Previous Studies

The immediate vicinity of Atlin has been the subject of two previous studies. The first study, in the fall of 1974, concentrated on the redevelopment of an abandoned site on Pine Creek. Estimates based on the cost of the Clayton Falls plant at Bella Coola indicated that the cost of a 1 MW plant would exceed $900/kW and the scheme was deemed uneconomic.

The second study, in 1978 and 1979 as part of Engineering Assignment 477-081[1], again considered the redevelopment of the abandoned site. The study considered extending the head canal and relocating the powerhouse to increase the installed capacity to 2.2 MW.

A scheme on Fourth of July Creek, to the north of Atlin, was also studied. It also consisted of a head canal, a penstock and a powerhouse. The studies were aimed at establishing order-of-magnitude costs and were not pursued further.

c) Reconnaissance

Atlin has a comparatively low rainfall and harsh winters. As a result, the survey itinerary concentrated on sites with natural storage which might be enhanced to afford some regulation of snowmelt runoff and provide some protection against frazil and anchor ice in the winter. The sites visited (Fig. 2) were:

1. Pine Creek and Surprise Lake
2. Atlin River between Atlin Lake and Graham Inlet,
3. Indian Creek and Lake (shown on some maps as Tele-cabin Creek and Porter Lake),
4. Fourth of July Creek and McDonald and Lower McDonald Lakes,

d) Development Potential

i) Pine Creek

Pine Creek clearly offers the most promise for development. In addition to the abandoned plant, there is

another site with a potential of about 1 MW a short distance upstream of Atlin airstrip. Previous studies have shown that good flow regulation can be achieved by providing as little as 1 m depth of storage at Surprise Lake. The 1978/79 proposal to extend the head canal of the abandoned plant to gain more head would probably be impracticable because of uneven ground and tributary gullies.

There are two pending applications for water rights to develop Pine Creek, which is an active placer mining area. Placer Development Ltd. has applied for rights to develop the full potential of the site, to supply some 6-7 average MW of the 12 MW required for their proposed Adanac molybdenum mine at Surprise Lake. The proposed 10 MW development would involve two powerhouses which would each develop approximately half the head available between Surprise Lake and Atlin Lake. One powerhouse would be located near Pine Creek and the other on the shore of Atlin Lake. Flow to the second powerhouse would be supplemented by diversion from a tributary, Spruce Creek. Placer Development hold the surface rights in the area of key project components and appear to have maintained a map reserve throughout the Pine Creek valley.

Energy Exploration Ltd., a company formed specifically to develop small hydro projects, has applied for water rights to develop the site with the intention of selling the energy to B.C. Hydro and Placer Development Ltd.

ii) Atlin River

The Atlin River falls 12 m between Atlin Lake and Graham Inlet and has a regulated potential of about 15 MW. A

submarine cable would be required to supply power to Atlin townsite. The site would probably prove uneconomic for capacities much less than the full potential and it is not therefore a promising site for B.C. Hydro's need alone. However, the Northern Canada Power Commission (NCPC) has studied flow regulation facilities at the site to improve generation at their Whitehorse Rapids plant downstream. At one time they offered B.C. Hydro the opportunity of a power development, but this was rejected on the grounds that regulation would probably involve prohibitively expensive fisheries studies and that the development would be dependent upon the sale of most of the generation to NCPC. Further studies by NCPC reduced the amount of regulation and deleted the power development. NCPC is not proceeding with the project at present because of the lack of load growth in the Yukon.

iii) Indian Creek

Regarding Indian Creek, the bed was completely dry and there was no visible surface outfall from Indian Lake. The site clearly has no small hydro development potential.

iv) Fourth of July Creek and McDonald Lakes

Unlike Surprise Lake, both of the McDonald lakes were already frozen (in October) and Fourth of July Creek had extensive anchor ice. The comparatively early ice formation suggests that the lakes are very shallow. Since the total surface area of the lakes is a small fraction of that of Surprise Lake, a correspondingly larger dam would be required, not only to achieve the same degree of regulation but to afford the same protection against ice formation. In addition, the drainage area of the lakes is

appreciably less than that of Surprise Lake while the head which could be developed is only slightly more. Fourth of July Creek therefore offers appreciably less promise than Pine Creek.

3.2 Fort Nelson

a) Existing Service

B.C. Hydro's generating station has both natural gas and diesel units with a total installed capacity of 25,800 kW. The peak demand in 1982/83 was 13,400 kW and the annual energy was 57.49 GWh, both slightly less than in 1981/82.

b) Previous Studies

The area was included in the inventory studies performed in 1978 by HGPD under engineering assignment 477-081[1]. Two sites were considered, based on review of 1 in 50,000 scale topographic maps, one on the Prophet River about 20 km from Fort Nelson and one on the Muskwa River some 70 km from the town. The studies were aimed essentially at replacing the existing service and both sites required extremely costly dams to provide sufficient head and storage, and were not economic.

c) Reconnaissance

One extended flight was made, covering the Prophet and Muskwa Rivers, Etane and Tsoo Creeks (in a area of high ground about 70 km to the north-west of Fort Nelson), and the Fort Nelson River between Tsoo Creek and the town.

d) Development Potential

Etane Creek bed was dry and Tsoo Creek was frozen. Neither offered any promise, even for a micro hydro development.

The main rivers are sluggish, meandering and turbid, and offer little or no promise as hydro resources.

3.3 Queen Charlotte Islands

a) Existing Service

B.C. Hydro has two separate diesel stations and distribution systems on the islands. The largest station, near Masset in the north of Graham Island, has an installed capacity of 9,424 kW. The peak demand in 1982/83 was 3,400 kW and the annual energy was 18.43 GWh. The station also supplies power to Port Clements by a 25 kV distribution line.

The second station, at Sandspit at the north-east tip of Moresby Island, has an installed capacity of 7,400 kW. The peak demand in 1982/83 was 3,500 kW and the annual energy was 17.73 GWh. The station also supplies power to Queen Charlotte City by a 25 kV cable under Skidegate Inlet and by a single-phase line as far north as Tlell.

For both stations, the peak demand was slightly less than in 1981/82 while slightly more energy was supplied.

b) Previous Studies

The islands have been the subject of several hydro and other alternate power supply studies. Most of these studies are covered in a report prepared by SED in 1983[2]. Among studies not covered in the report are pre-feasibility level hydro studies performed by HGPD during 1978 and 1979 as part of engineering assignment 477-081[1]. Sites which have been studied include:

Yakoun River
Honna River
Naden River - Lignite Creek
Ain River

Results indicate that the Ain River is the most promising site. However, like most rivers on the islands, the Ain has a significant anadromous fish population. At least two preliminary assessments have been made of the environmental impacts of a dam and hydro plant and the mitigative measures that might be required. Detailed fisheries studies have yet to be undertaken. In 1974, a two-year fisheries study was estimated to cost $250,000.

The SED report recommended a preliminary investigation of the effects of hydro generation on anadromous fish stocks in the Ain and Naden Rivers and a detailed investigation of the feasibility of a hydro project on the Ain River.

c) Reconnaissance

The terrain of the eastern side of the islands in the vicinity of the two load centres is generally low lying; the rivers and streams have shallow gradients and offer no

promising natural small hydro sites. Previous studies were aimed at replacing the existing diesel service and had to resort to extensive civil works in the form of dams, tunnels and penstocks to provide enough storage and head for even moderate capacities from 4 MW to 11 MW.

The reconnaissance itinerary for the islands took into consideration the extent of previous studies and included visits to the main sites, but concentrated on inspecting the lakes and mountainous terrain to the west and south of the load centres for possible high-head schemes to supply partial fuel displacement energy, rather than to replace the existing service. The sites visited (Fig. 3) were:

1. Skidegate Lake,
2. Mosquito Lake,
3. Two lakes and falls south of Mosquito Lake on the north shore of Kuper Inlet,
4. Three lakes on the west coast between Cape Henry and Tasu Sound
5. Lakes and falls at the head of Van Inlet,
6. Goudal Creek, lakes and falls,
7. Moresby Lake,
8. A lake and falls above Moresby Lake (referred to as upper Moresby Lake),
9. Ain River and Lake, Ian Lake, Skundale Lake,
10. Naden River and Lignite Creek,
11. Yakoun River

d) Development Potential

Skidegate and Mosquito Lakes were visited largely because they were on the flight path to sites in the south-west. The lake outlets have no falls. Any development would

involve civil works at least as expensive as those for the Ain River but the yield would be much lower and the environmental impacts would be no less significant.

Of the sites visited to the west and south, four showed no promise because of insufficient head and/or flow. They were:

the most westerly of the two lakes to the south of Mosquito Lake,
the three west-coast lakes.

Sites which showed some promise for small hydro development because of substantial head were:

the lakes and falls at the head of Van Inlet (the available head between the middle and lowest lake was estimated from helicopter altimeter readings to be in excess of 250 m),

Goudal Creek (the available head between the upper and lower lakes was estimated to be 390m; the majority of inflow occurs below upper lake and the best intake site is at falls at about El. 230),

the eastern of the two perched lakes to the south of Mosquito Lakes (available head was estimated to be approximately 450 m),

Moresby Lake and upper Moresby Lake (the available head was estimated to be in excess of 100 m and 450 m respectively).

The obvious disadvantages of these sites are their small drainage areas and remote locations. Installed capacities are unlikely to exceed 1.5 MW, and transmission and access costs would be very high.

Regarding sites studied previously, it did not appear from the air as if a dam of the height envisaged for the Ain River scheme, at the outlet of Ain Lake, would be feasible. However, the site has been visited on foot and the impression from the air, that the ground on either bank is too low, may well be wrong. No other sites were identified.

The site for a dam on the Naden River, at some extremely low falls below Indian Reserve (I.R.) 9 appears quite inappropriate. The valley is broad and flat bottomed and, at best, any dam would be extremely long and would flood a substantial proportion of the valley, including I.R.9. No other sites were identified.

No sites were identified on the Yakoun River. The scheme to divert water from Yakoun to Shields Bay remains a possibility but environmental impacts and mitigative measures have yet to be assessed. In any event, the 1978/79 HGPD study indicated the scheme would have a smaller installed capacity than the Ain and cost approximately 50% more. Unless environmental factors preclude the Ain development, the Yakoun scheme offers little promise.

3.4 Stewart

a) Existing Service

B.C. Hydro's diesel station supplies domestic and commercial demand in the area, including Hyder, Alaska. The installed capacity is 7,247 kW. The peak demand in 1982/83 was 3,020 kW and the annual energy was 13.37 GWh. Mines in the area provide their own power.

b) Previous Studies

The Generation Planning Department of SED made a field reconnaissance visit in July 1981 and a draft preliminary site selection study report was prepared in November 1981[3]. Five sites were recommended for further study:

Cascade River,
Glacier Creek,
Barney Gulch,
Kate Ryan Creek,
Bulldog Creek.

Cascade River was deemed the most promising site, with Glacier Creek also offering possibilities. The study used flows derived from runoff factors for other, gauged, basins in the area and the report recommended a stream gauging program of all five sites to verify available flows.

c) Reconnaissance

An initial general reconnaissance was made of all likely rivers and streams in the area. The sites inspected (Fig. 4) were:

1. Cascade River,
2. Bear River,
3. Marmot River,
4. American Creek,
5. Bulldog Creek,
6. Kate Ryan Creek,
7. Barney Gulch,
8. Glacier Creek

A more detailed reconnaissance was then made of the Cascade River with a brief return visit to Glacier Creek.

d) Development Potential

The general reconnaissance confirmed the previous study finding that the Cascade River offers the greatest potential for development. The river is not solely glacier fed, natural storage is available in several lakes and there are at least three potential sites (Fig. 4) where substantial changes in elevation occur over short distances. Road access is available within a short distance along most of the river's length. The main disadvantage is the transmission distance. The river is a tributary of the Salmon River and lies in a valley to the west of Stewart and is separated from it by the Bear River Ridge. The confluence of the two rivers is just inside Alaska and the access road passes through the U.S.

The more detailed reconnaissance covered the full length of the Cascade River. Two of the three potential sites identified have derelict small hydro developments. The first is at the head of the river at the outlet of Long Lake. The scheme developed a head of some 150 m with a woodstave penstock and two short tunnels. The intake is located in Long Lake and a dam at the outlet of the lake provided storage. The dam was apparently breached for safety reasons in 1980. Subsequent research revealed a water license application for this site filed in 1981, apparently by the site owners, Western Mines Ltd.

The second derelict scheme is just upstream of the confluence with the Salmon River, near the Premier mining camp. It developed a head of approximately 60 m with a small diversion structure and a flume and penstock. Subsequent research revealed an existing water license for this site.

The third potential site is near the confluence with Silver Creek immediately downstream of the derelict scheme at Long Lake. A head from 30 m to 100 m could be developed, either in a separate scheme or combined with the derelict scheme.

A possible fourth site upstream of the lower derelict scheme was, on closer inspection, found to be unsuitable because the falls appear to have been produced by a large rock fall from the left side of the valley.

The scheme suggested in the 1981 SED report[3], namely, to develop the head between the confluence with Silver Creek and the road crossing of the Cascade River, is the least attractive on the river. Not only is the overall gradient

of the reach quite a bit less than the others, requiring a longer penstock to develop the same head, but the penstock would have to pass through a valley with very loose and potentially unstable sides.

Energy Exploration Ltd. has applied for a water license to develop a 1,200 kW plant utilizing the available head between the two derelict plants. This application together with Western Mines' application and the existing water license cover the full potential of the river.

All the other sites are situated in the same valley as Stewart and either flow directly into Portland Canal or are tributaries of the Bear River. However, all are essentially glacier fed and experience very low winter flows. Only the Bear River has natural storage and even that is considerably less than on the Cascade River. The Bear River, Marmot River and American Creek have comparatively shallow gradients with few rapids or falls and no suitable sites were identified.

Further disadvantages of other sites compared with the Cascade River are:

Bulldog Creek: extremely difficult access (flows directly into Portland Canal, 8½ km from Stewart), possible requirement for transmission by submarine cable, less flow;

Kate Ryan Creek: difficult access (tributary of Marmot River which flows direcly into Portland Canal), less flow;

Barney Gulch: substantially less flow, difficult access for construction of penstock and intake;

Glacier Creek: difficult access for construction of intake and penstock (creek flows in a deeply incised gorge in the floor of glacial valley).

3.5 Anahim and Tatla Lakes

The Anahim and Tatla Lakes districts are situated close together, although they are not interconnected. They have been grouped together for the purpose of this report because the field reconnaissance surveys were conducted at the same time and because subsequent brief office studies considered supplying both districts from one site.

a) Existing Service

The Anahim district is served by a 1,600 kW diesel plant. A distribution line extends to Nimpo Lake. The peak demand in 1982/83 was 570 kW and the annual energy was 2.28 GWh.

The Tatla district is served by a 1,300 kW diesel plant. Distribution lines extend to Kleena Kleene and Tatlayoko Lake. The peak demand in 1982/83 was 260 KW and the annual energy was 0.94 GWh.

b) Previous Studies

The Anahim area has been included in two previous studies. The first study, under Engineering Assignment 477-081,

tentatively identified three potential sites, the outlet from Charlotte Lake on the Atnarko River, the outlet from Hotnarko Lake on the Hotnarko River and Young Creek.

The second study was performed by Sigma Engineering Ltd. as the site selection stage of a small hydro feasibility study of the Bella Coola - Anahim Lake area. The object of the Stage I selection study was to identify the preferred site for early development to serve either community. The Atnarko and Hotnarko sites were discarded early in the study in favour of more economic schemes in the Bella Coola area. Young Creek was studied in more detail because it appeared to have the potential to serve both communities. It was eventually discarded following a field reconnaissance which indicated that the steep valley sides were prone to slides. A layout minimizing the risk to the penstock would have required locating the powerhouse at least 1 km downstream from a series of falls designated as the upstream limit of Steelhead migration, thus introducing potentially troublesome environmental impacts.

The Tatla area was also included in the studies under Engineering Assignment 477-081 and a potential of 2.6 MW was indicated utilizing the head between Eagle Lake and Tatla Lake.

c) Reconnaissance

Both districts are situated on the Chilcotin plateau, an area of generally low rainfall. Streamflows in the area are generally highest in early summer due to snowmelt and are lowest in the winter when snow is accumulating. The reconnaissance survey therefore concentrated on sites with

natural storage which could be utilized to regulate snowmelt runoff and augment winter flows to match the load shape.

An initial general reconnaissance was made of all likely sites. The sites visited (Fig. 5) were:

1. Charlotte Lake, Little Charlotte Lake and the Atnarko River immediately downstream,

2. Hunlen Falls,

3. Hotnarko Lake and River,

4. Young Creek,

5. Eagle Lake.

A more detailed reconnaissance was then made of Charlotte Lake. The historic high and low water marks, current lake level, outlet discharge and outlet dimensions were measured. The flow in Young Creek was also gauged at three locations.

Another visit was made to Charlotte Lake in July 1983 to measure the lake level and discharge at the outlet.

d) Development Potential

i) Charlotte Lake and the Atnarko River

Charlotte Lake and the Atnarko River downstream of it clearly offer the most promise for development. There is a natural site for a regulating structure at the outfall

from Charlotte Lake (Fig. 5). The river then flows down a short canyon and rapids into Little Charlotte Lake. The difference in elevation between the two lakes was estimated to be about 7.5 m.

There is another possible site for a regulating structure in a short canyon with rapids at the outfall from Little Charlotte Lake, 3 km downstream of Charlotte Lake. Due to the heavy tree cover, it was not possible to determine the elevation of the ground immediately surrounding the site but it is believed that a structure could be built which would raise the level of Little Charlotte Lake to that of Charlotte Lake and develop a head of 12 to 15 m. Beyond Little Charlotte Lake, the Atnarko River flows at a comparatively shallow gradient for 9 km to a third possible site where the gradient of the river steepens appreciably. There is a good site for an intake at the top of a short bedrock water chute at this point. The gradient of the river from this point is approximately 54 m/km for 2 km before the river crosses the boundary of Tweedsmuir Provincial Park. Thereafter, the gradient of the river almost doubles, to 98 m/km, but any development would be located entirely within the park and would be likely to encounter licensing problems.

The disadvantages of these sites are the long access and transmission requirements, particularly to the site immediately above the park boundary.

ii) Hunlen Falls

Although Hunlen Falls could provide some 600 m of head, the site is the furthest from Anahim and is situated on the opposite side of a steep-walled gorge. The site

itself is precipitous. It is also a regional landmark and tourist resource located entirely within the Tweedsmuir Provincial Park. As a result, development would encounter major technical and environmental problems which would very likely render it unfeasible.

iii) Hotnarko Lake and River

Regarding the Hotnarko basin, although the basin itself is quite large, the drainage area of Hotnarko Lake is small. The lake is perched on a flat columnar basalt tableland. The lake appears to be very shallow and no suitable site for a regulating structure could be found. The major contribution to the flow of the river is believed to be Telegraph Creek, which enters the Hotnarko River where it crosses the boundary of Tweedsmuir Provincial Park. While the gradient of the river is steep beyond this point, the river flows in a deeply incised gorge and access and transmission would be difficult and costly. In addition, it would not be possible to provide sufficient storage to regulate the flow of Telegraph Creek. Although the Hotnarko River is physically closer to Anahim than Charlotte Lake, it is considered to be far less promising.

iv) Young Creek

The reconnaissance of Young Creek confirmed the findings of the study by Sigma Engineering Ltd. Although the available head and flow provide potential for development, the steep, unstable, walls of the valley would render such a development extremely costly.

v) Eagle Lake

Although available maps indicate a stream flowing from Eagle Lake to Tatla Lake, the reconnaissance showed the bed to be dry. In fact, an access road embankment has been constructed across it immediately adjacent to the lake and only a small culvert has been provided. No other surface outfall was observed. Eagle Lake is therefore quite unsuitable for development.

4.0 ASSESSMENT OF CHARLOTTE LAKE DEVELOPMENT

4.1 General

Because Charlotte Lake was the only promising site in the six diesel districts visited which was not the subject of a prior application for water rights by others, it was decided that a further assessment should be made.

4.2 Hydrology

Charlotte Lake is located in the headwaters of the Atnarko River. It is unregulated and has not been gauged previously, either for inflows, outflows or lake level. The only streamflow gauge in the vicinity, Atnarko River near the Mouth (Water Survey of Canada - 8FB006), is located 90 km downstream of Charlotte Lake. The gauge has been in operation since May 1965. The drainage area at the gauge is 2430 km^2 compared to 652 km^2 at Charlotte Lake outlet.

Direct estimation of monthly Charlotte Lake inflows from the unit area runoff at gauge 8FB006 was not considered reliable without additional checks, due to the location of Charlotte Lake in the Atnarko River basin. Charlotte Lake is located at

the eastern extremity of the basin in the downslope of the last major mountain barrier of the coast range. The lake is adjacent to the interior plateau. Annual precipitation varies across the coast mountains with a trend proceeding inland toward lesser amounts due to moisture depletion of the air mass. The land immediately to the east is in a noticeably drier climatic zone. Also, varying penetrations of warm Pacific air masses into the basin in the spring are felt to produce earlier spring runoff in the portion of the Atnarko watershed east of Charlotte Lake.

The hydrologic data collected during the two site visits were used to establish a stage - discharge curve for Charlotte Lake outfall.

Trial reservoir routings were carried out for the period 1965 to 1983 in order to establish the representativeness of the monthly unit area runoffs from gauge 8FB006 as inflows to Charlotte Lake. The criteria for acceptance were the ability of the inflows to reproduce both the high and low-water marks. The adjusted inflows were used in combination with the stage-discharge and stage-storage relationships developed from site measurements and 1 in 50,000 scale maps. Trial-and-error reservoir routing simulations were also made to modify and verify the shape of the stage-discharge curve. Monthly unit-area runoffs from gauge 8FB006, when reduced by 5 percent, reproduced the high and low-water marks. These inflows were considered sufficiently accurate for use in power studies. The mean annual Charlotte Lake inflow for the 19 year period was 8.0 m^3/s. Field observations in 1983 revealed that the spring increase in runoff at Charlotte Lake that year occurred one month later than at gauge 8FB006.

Further reservoir routings were undertaken to assess the potential of storage at Charlotte Lake to modify outflows to match the seasonal variation in load demand. The 19 years of inflows were used along with trial outflows proportioned on the basis of the monthly distribution of Anahim Lake gross kWh production for 1982 (assumed to be a typical distribution). The observed variation in Charlotte Lake levels of 1.7 m was assumed to be the maximum allowable variation for the routings. Spillage was assumed for excess inflows with the lake at the historic high-water mark in order to avoid further increase in levels. Similarily, a shortfall in power generation was assumed at the historic low-water mark when inflows did not match required power flows. For each trial reservoir routing the number of shortfalls and spills over the 19 year period were recorded. The results are shown in Table 1.

4.3 Development Potential

Assuming a modest development at the outfall of Charlotte Lake, consisting of a regulating structure and short power conduit to a powerhouse on the shore of Little Charlotte Lake, the mean head available would be some 8 m. With a regulated maximum power flow of 8.2 m^3/s (trial routing D), the development could have a generating capacity of 550 kW and produce 3.7 GWh of energy annually (76% annual capacity factor). Based on the five-year loss criterion discussed earlier, and using Fig. 1, approximately $5,500/kW could be expended to construct the plant, i.e. the maximum capital cost including overhead would be approximately $3,000,000.

However, inspection of the generation figures for the Anahim Lake diesel station shows a very low load factor of 46%. Not only would the conceptual plant at Charlotte Lake have been unable to satisfy the 1982/83 peak requirement (570 kW) but

only 2.28 GWh of its 3.7 GWh potential energy output could have been used, i.e. only 62%. Furthermore, load growth projections do not indicate an appreciable increase in demand over the next six years. The generating capacity and maximum capital cost considered above must therefore be reduced.

Assuming a regulation pattern to match seasonal variation in load similar to that used in the trial routings (i.e. a 76% annual capacity factor), a plant of approximately 340 kW should be installed, at a maximum capital cost of some $1,900,000. Connection to the Anahim Lake district grid at Nimpo Lake would require at least 34 km of 25 kV transmission line at an approximate cost of $850,000. The project would also require an access road some 25 km long, which would cost at least $250,000. These costs would leave $800,000, or $2,350/kW, for construction of the plant itself, which is inadequate.

Consideration was then given to better utilizing the energy output of the larger plant by supplying both Anahim and Tatla Lakes districts. However, Tatla Lake has an even lower load factor (41%) than Anahim Lake. The peak demand would increase to 830 kW but the total energy requirement, 3.22 GWH, would still be less than the plant's potential. In addition, at least a further 34 km of 25 kV transmission line would be required to connect to the Tatla district grid at Klee.a Kleene. The $850,000 required to construct this transmission line would almost offset the increase in allowable maximum capital cost and hence do little to improve the economics of the plant.

The possibility of developing the Bowl Lake component of the Homathko Project to serve Tatla, Anahim and Bella Coola was also briefly investigated. However, such a development would require interconnection to Williams Lake to utilize the major

proportion of the approximate 20 MW potential of the site. It was found that transmission costs to avoid problems of instability and voltage drop in the event of a plant outage would render the development uneconomic.

5.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Small hydro studies to date indicate the following:

a) That there are no suitable sites for development in the Fort Nelson and Tatla Lake districts.

b) That there are potential sites in the Stewart and Atlin districts but development by B.C. Hydro would be subject to prior development claims by others. The cost effectiveness of these sites was not assessed.

c) That the Ain River site is the most promising in the Queen Charlotte Islands but the site has potentially overriding environmental constraints. The cost effectiveness of this site was not assessed.

d) That a potential development at Charlotte Lake to supply electric power to the districts of Anahim Lake and Tatla Lake would be uneconomic based on the present load forecast and the five-year loss criterion specified in draft corporate small-scale energy development policy.

4.2 Recommendations

Based upon studies to date, it is recommended that:

a) No further studies be planned for Fort Nelson or Tatla Lake Districts.

b) That further studies of potential sites in the Stewart and Atlin districts be considered if prior development claims by others are relinquished.

c) That studies of other Queen Charlotte Islands sites be postponed until the Ain River scheme and its effect on anadromous fish have been studied.

d) That further studies of potential sites in the Anahim Lake district be considered only if there is a large increase in the load or if the adopted economic criteria are less restrictive than those currently proposed in draft corporate policy for small-scale energy resource development.

REFERENCES

1. British Columbia Hydro and Power Authority. Hydroelectric Generation Projects Division. 11 January 1980. Inventory of Small Hydro Sites near Diesel Plants in Remote Locations - Assignment 477-081. Memorandum F.J. Patterson to H.J. Goldie.

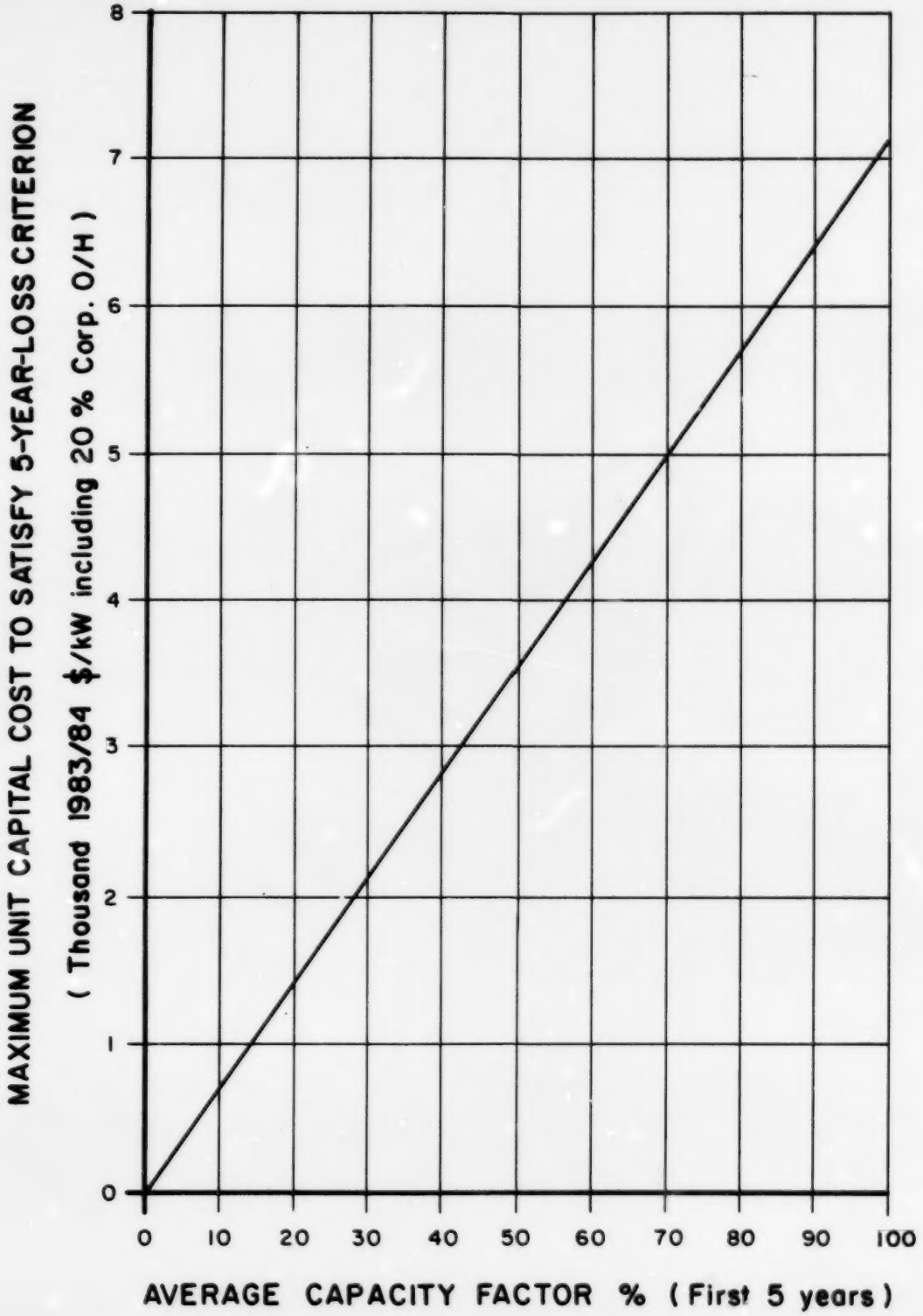
2. British Columbia Hydro and Power Authority. System Engineering Division. May 1983. Queen Charlotte Island Power Supply Preliminary Evaluation. Report No. SE 8106.

3. British Columbia Hydro and Power Authority. System Engineering Division. November 1981. Hydroelectric Site Selection Study - Stewart. Draft Report.

TABLE 1

CHARLOTTE LAKE REGULATED MONTHLY OUTFLOWS (EXCLUDING SPILL)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	No. of Shortfall Occurrences	No. of Spilling Occurrences
1982 Dist %	10.4	9.7	9.4	7.8	7.0	7.6	6.5	6.8	7.0	7.8	9.2	10.8	-		
Trial A (m^3/s)	8.3	7.8	7.5	6.2	5.6	6.1	5.2	5.4	5.6	6.2	7.4	8.6	6.7	3	11
B	8.2	7.7	7.4	6.2	5.5	6.0	5.1	5.4	5.5	6.2	7.3	8.5	6.6	2	12
C	8.1	7.6	7.3	6.1	5.5	5.9	5.1	5.3	5.5	6.1	7.2	8.4	6.5	1	14
D	7.9	7.4	7.1	5.9	5.3	5.8	4.9	5.2	5.3	5.9	7.0	8.2	6.3	0	14



N O T E:.

ASSUMES THE SAME DISTRIBUTION OF CAPITAL COST OVER TIME AS THE ORIGINAL 1250 kW DESIGN FOR THORSEN CREEK PROJECT.

FIG. 1

KEY PLAN

SITES:

1. PINE CREEK AND SURPRISE LAKE
2. ATLIN RIVER BETWEEN ATLIN LAKE AND GRAHAM INLET
3. INDIAN CREEK AND LAKE (SHOWN AS TELE-CABIN CREEK AND PORTER LAKE)
4. FOURTH OF JULY CREEK AND MCDONALD LAKES

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SMALL HYDRO STUDIES

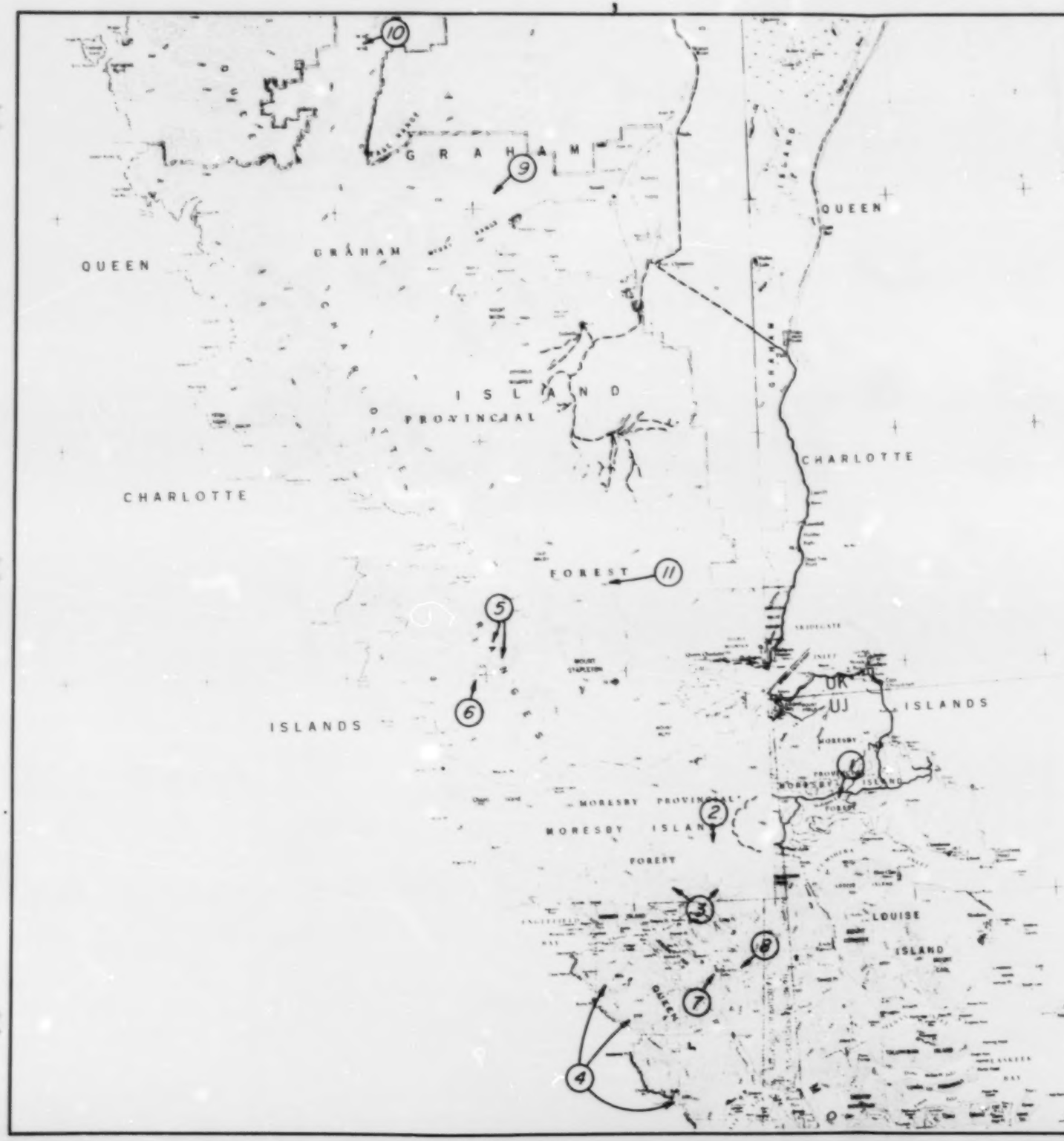
SITE RECONNAISSANCE

ATLIN

SITE LOCATION PLAN

DATE OCT 1984	FIG 2
DWN FM	DWG. No G-C14-B320

REPORT No. H1771



KEY PLAN

SITES:

1. SKIDEGATE LAKE
2. MOSQUITO LAKE
3. LAKES TO THE NORTH OF KUPER INLET
4. WEST COAST LAKES
5. LAKES AND FALLS AT THE HEAD OF VAN INLET
6. GOUDAL CREEK
7. MORESBY LAKE
8. UPPER MORESBY LAKE
9. AIN RIVER AND LAKE, IAN LAKE, SKUNDALE LAKE
10. NADEN RIVER AND LIGNITE CREEK
11. YAKOUN RIVER

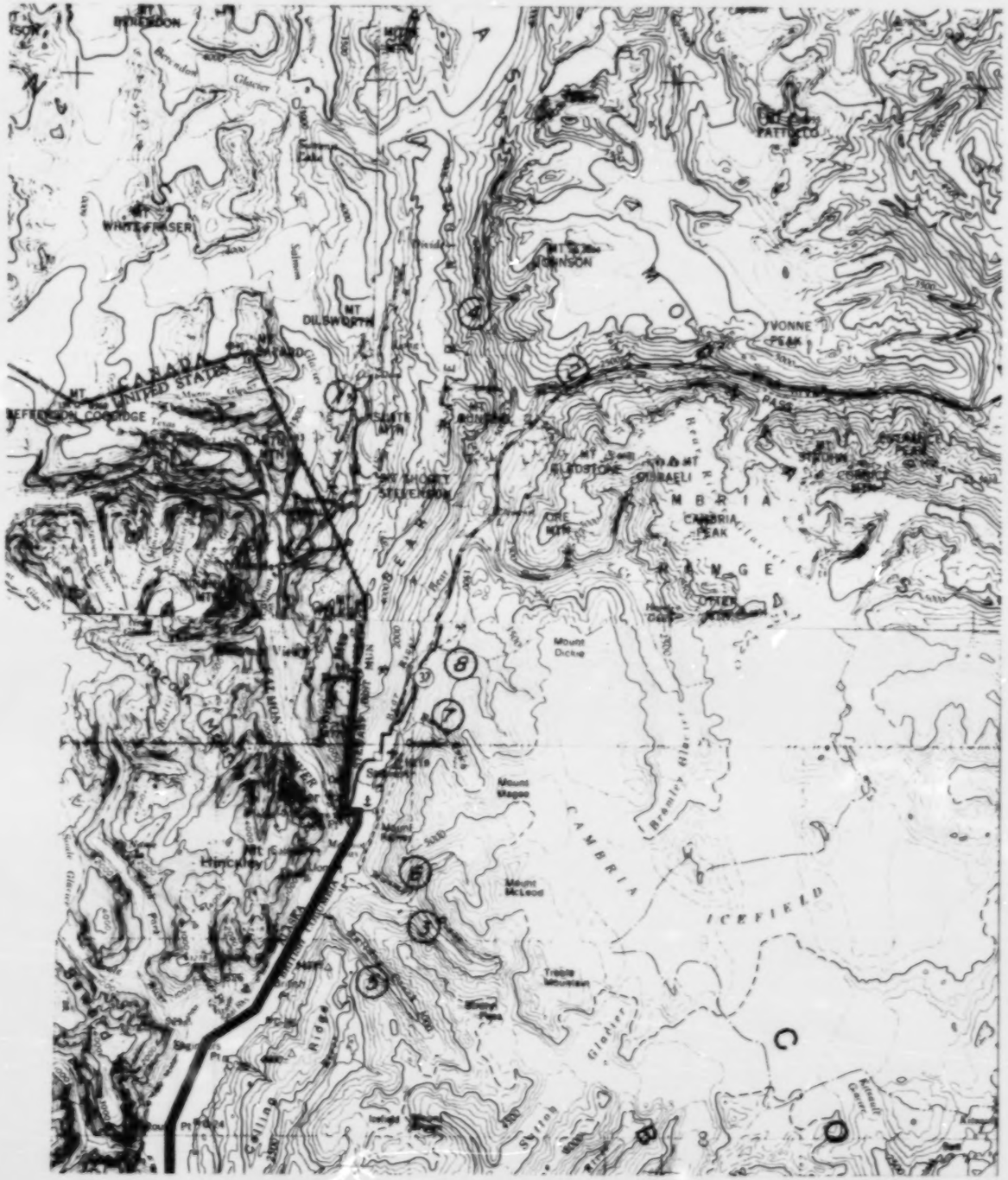
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SMALL HYDRO STUDIES

SITE RECONNAISSANCE
QUEEN CHARLOTTE ISLANDS
SITE LOCATION PLAN

DATE OCT 1984	FIG 3
DWN FM	DWG No G-C14-B321

REPORT No. H1771



KEY PLAN

SITES:

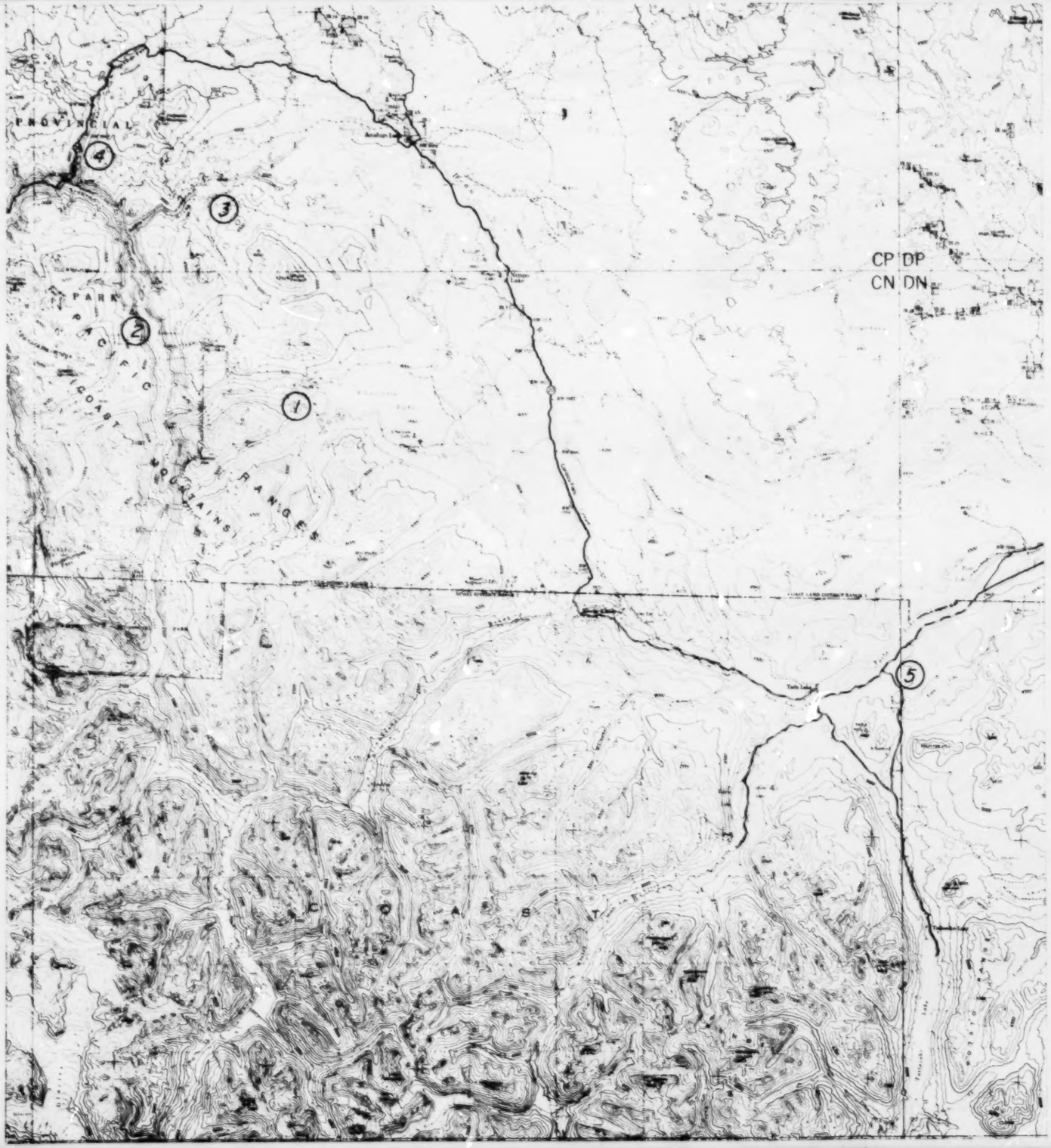
1. CASCADE RIVER
2. BEAR RIVER
3. MARMOT RIVER
4. AMERICAN CREEK
5. BULLDOG CREEK
6. KATE RYAN CREEK
7. BARNEY GULCH
8. GLACIER CREEK

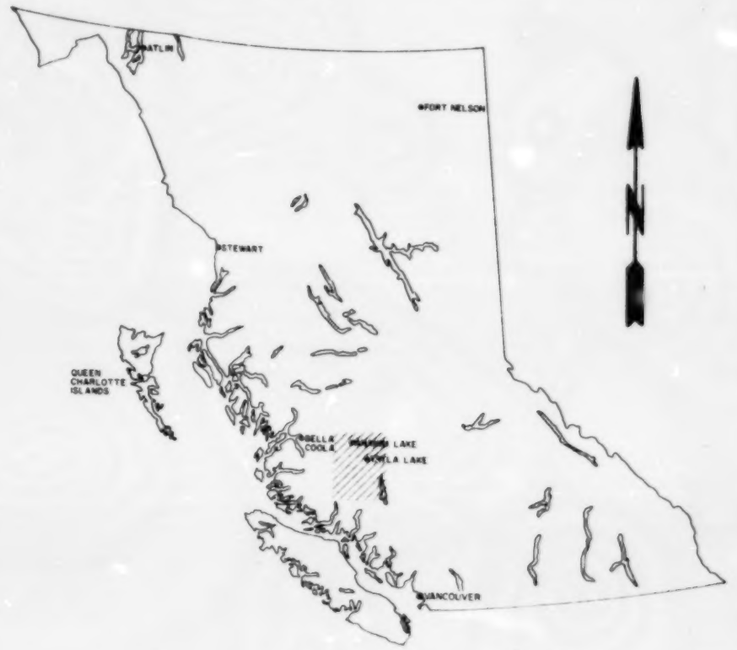
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SMALL HYDRO STUDIES
SITE RECONNAISSANCE
STEWART
SITE LOCATION PLAN

DATE OCT 1984	FIG 4
DWN FM	DWG. No G-C14-B322

REPORT No H1771





KEY PLAN

SITES:

1. CHARLOTTE LAKE AND ATNARKO RIVER
2. HUNLEN FALLS
3. HOTNARKO LAKE AND RIVER
4. YOUNG CREEK
5. EAGLE LAKE

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

SMALL HYDRO STUDIES

SITE RECONNAISSANCE

ANAHIM AND TATLA LAKES

SITE LOCATION PLAN

DATE OCT 1984	FIG 5
DWN F M	DWG No. G-C14-B323

REPORT No. H1771

POOR

QUALITY

ORIGINAL